Documentation for `SimulationScan.sh`

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`SimulationScan.sh` is a `Bash` script which automates the simulation of high energy particle collisions. These simulations are crucial for predicting signatures of new, undiscovered particles at particle accelerators such as the Large Hadron Collider. Variants of `SimulationScan.sh` were extensively used in [1] to study signatures of new particles at "future colliders", which have been proposed as successors to the Large Hadron Collider.

`SimulationScan.sh` is specifically designed to study a class of new physics models known as *Supersymmetry*. For our purposes, the key consequence of Supersymmetry is the prediction that each "ordinary" particle (e.g. electrons, quarks, photons, etc.) has a "Supersymmetric" partner. This version of `SimulationScan.sh` focuses in particular on *squarks*, the Supersymmetric partner to quarks, and the *gluino*, the Supersymmetric partner to the gluon. One goal of the Large Hadron Collider is to collide high energy protons, with the hope of producing squarks and/or gluinos from these collisions. If squarks and/or gluinos are produced, detectors near the collision point can be used to observe the resulting signature.

`SimulationScan.sh` utilizes multiple (free) software packages commonly used in the particle physics community. A list and descriptions of these pre-requiste packages are described, in order of their execution within the script:

1. **Model Generator**: `SOFTSUSY` v3.5.2. The first step of the simulation pipeline is to generate a model. To this end we use `SOFTSUSY,` which takes the file `input.dat` and generates a Supersymmetric model. The input file `input.dat` requires more than a dozen input parameters. For simplicity we impose relations between various parameters so that `input.dat` only contains 2 free parameters: `M0` and `M3`. The path to `SOFTSUSY` should be set to `$SOFTSUSYDIR`.

2. **Decay Rate Calculator**: `SDECAY` v1.1a. Given the model from `SOFTSUSY` (stored in `output.dat),` the decay rates of squarks and gluinos must be calculated to make accurate predictions. We use the version of `SDECAY` contained within the `MADGRAPH` Tools package available in the above link. The path to the decay rate calculator should be set to `$CalcDIR`.

3. **Monte-Carlo Simulations of Particle Collisions**: `MADGRAPH5` v2.2.3. The final step is the Monte-Carlo simulation of particle collisions for the model generated through the preceeding steps. `MADGRAPH5` simulates both the underlying physics of the particle collision *and* the resulting detector response. Note that `SimulationScan.sh` assumes that detector simulation is performed via `Delphes3,` which can be installed via the `MADGRAPH5` interface. In order to use `SimulationScan.sh,` a process folder must have already been defined within `MADGRAPH5.` The path to this process folder should be set to `$MADGRAPHPROCDIR` . For details regarding generating a process in `MADGRAPH5,` see the `MADGRAPH5` webpage.

In addition to automating excecution of the above programs, `SimulationScan.sh` is able to perform a grid scan over values of the input parameters `M0` and `M3` (which correspond roughly to squark and gluino masses). Specifically `SimulationScan.sh` scans over values of `M0` from `M0i` to `M0i` + (`imax` -1) × `dM0` for `M0`, and scans over values of `M3` from `M3i` to `M3i` + (`jmax` -1) × `dM3`. These parameters can be set in the beginning of the script. For each parameter point, `SimulationScan.sh` saves the resulting simulation output (.root file) along with information regarding the model (.txt file) into the user-defined output directory `OUTDIR`.

References

[1] S. A. R. Ellis and B. Zheng, arXiv:1506.02644 [hep-ph]. To appear in Physical Review D.